

Filtration Processes Technical Bulletin

Ministry of the Environment

Safe Drinking Water Branch

A newsletter for OWWA, OMWA
and Drinking Water System Owners/
Operators

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Filtration Performance & Regulatory Requirements

1. Filtration

Filtration is a physical process which is used for the separation of solids from fluids by interposing a medium through which the fluid can pass, but the solids (or at least part of the solids) in the fluid are retained. It has to be emphasized that the separation is not complete, and it will depend on the pore size and the thickness of the medium as well as the mechanisms that occur during filtration.

2. Turbidity

Turbidity is a measurement used to assess the cloudiness of water caused by suspended particles such as clay, silt, finely divided organic and inorganic matter, plankton and other microscopic organisms. For the purpose of O.Reg 170/03, turbidity must be measured in Nephelometric Turbidity Unit (NTU). It measures the amount of light scattered when it bounces off the suspended particles. In general, the cloudier the water, the more light scatters and the higher the measured turbidity. Since filtration is a unit process that separates solids from water, performance / effectiveness of a filter is assessed by the quality of the filtered water's measured turbidity.

3. O.Reg. 170/03 Regulatory Requirements

If a drinking water system (DWS) is required to provide filtration, depending on the category of the system and the type of filtration process used by the system, a grab sample from each filter's effluent line must be taken and manually analyzed for turbidity at a specific frequency or, samples must be taken and analyzed for turbidity by continuous monitoring equipment serving each filter (**Schedule 16, 16-3 (1.) 6**).

When filter effluent turbidity is measured by continuous monitoring equipment, the equipment must have the capability of taking samples, testing and recording at a minimum frequency of 15 minutes. The equipment must record the date, time, sampling location and the test result. An alarm must sound when a test result exceeds 1.0 NTU (**Schedule 6, 6-5 (1) 2 and (1.1) 1**). If the continuous turbidity monitoring equipment is capable of testing more often than

The Drinking-Water Systems Regulation (O.Reg 170/03) under the Safe Drinking Water Act, 2002 (SWDA) came into effect in 2003. Starting April 1st 2010, the "performance of filtration process" will be assessed using calculations outlined in this Bulletin. The purpose of this update is to provide clarification on how the Ministry interprets certain sections of the Act and regulations in order that all drinking water system owners and/or operators have a common understanding of the requirements when assessing filter performance, and to ensure safe drinking water in Ontario. The following technical clarifications have been approved by the Director, Safe Drinking Water Branch, Ministry of the Environment.

For Inquiries Contact:
Ministry of the Environment
Safe Drinking Water Branch
2 St. Clair Avenue West, Toronto, ON, M4V 1L5
Tel: (416) 212-7318 Fax: (416) 314-6935

every 15 minutes (i.e. every 2 seconds) instead of recording all test results (i.e. 450 measurements) taken during each 15 minute interval, the equipment may be set to check and calculate "**minimum**", "**maximum**" and "**mean**" values for that interval (from the 450 points). All 3 results will be recorded at the end of the 15 minute period. The equipment must also record the sampling location, date of the tests conducted and time at the end of the 15 minute period.

Regardless of the result recording protocol used (all results or the 15 minute interval **maximum**, **minimum** and **mean** values), an alarm must sound every time a test result exceeds 1.0 NTU and the equipment must record every such test result as well as its sampling location, date and the time of the test (**Schedule 6, 6-5: (1) 2 and (1.1) 1**).

Upon written request from the DWS owner, regulatory relief on specific sampling, testing, monitoring and/or reporting requirements ("other regulatory relief") may be granted by the approving Director, if appropriate. On a case-by-case basis, the Director may impose conditions/special requirements in lieu of the requirements for which relief has been granted.

4. Turbidity Adverse Result Reporting and Corrective Action

Schedule 16, 16-3 (1) of O.Reg 170/03 defines an adverse test result for turbidity as:

If the drinking-water system is required to provide filtration and a report under subsection 18(1) of the Act has not been made in respect of turbidity in the proceeding 24 hours, a result indicating that turbidity exceeds 1.0 Nephelometric Turbidity Units (NTU) in,

- i. a grab sample of water taken from a filter effluent line, or*
- ii. two samples of water from a filter effluent line that are tested by continuous monitoring equipment, if,*
 - a. two samples were taken 15 minutes or more apart and the later of the two samples was the first sample that was taken 15 minutes or more after the earlier sample, and*
 - b. the filter effluent line is directing water to the next stage of the treatment process.*

Grab Sample

For systems where filtration is required and grab samples are allowed, any filter effluent grab sample test result that exceeds 1.0 NTU is an adverse test result with **one exception** - if no other adverse test result has been reported, for the purpose of section 18 of the SDWA within 24 hours, prior to this test result.

The adverse result must be reported by the owner / operating authority to the Ministry's Spill Action Centre (SAC), to the Medical Officer of Health (MOH) and, except for large municipal residential systems, to the operator of each designated facility served by the system (**Schedule 16, 16-5 and 16-6**).

Continuous Samples

According to **Schedule 6, 6-5 (1.1)1**, a DWS owner must ensure that, if using continuous monitoring equipment for sampling and testing turbidity of a filter effluent, the equipment meets certain standards including causing an alarm to sound if a test is above the maximum alarm standard of 1.0 NTU. This is a regulatory alarm.

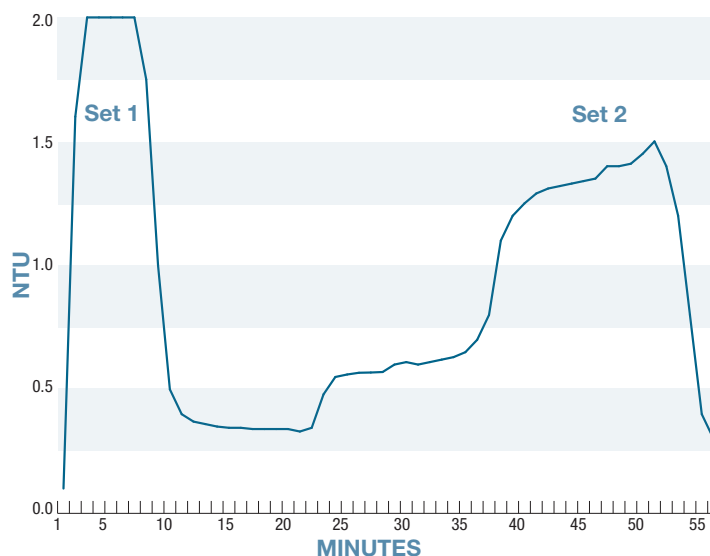
If two alarms (or two readings exceeding 1.0 NTU), 15 minutes interval or more ("more" referring to the first alarm or reading) apart, indicates that the filter turbidity has exceeded 1.0 NTU **and** the owner has not reported a turbidity exceedence in the 24 hours prior to this for the same filter **and** the filter effluent line is directing water to the next stage of the treatment process, then the turbidity exceedence is a prescribed adverse result for the purpose of section 18 of the SDWA. The adverse result must be reported by the owner / operating authority to the Ministry's Spill Action Centre (SAC), to the Medical Officer of Health

(MOH) and, except for large municipal residential systems, to the operator of each designated facility served by the system (**Schedule 16, 16-5 and 16-6**).

The following examples are provided to illustrate various scenarios.

Example 1 (see diagram below)

Readings are taken at 1 min. intervals. Set 1 readings are above 1.0 NTU & occurred from T=2 to T=9 min. Maximum time between 2 results exceeding 1.0 NTU is 7 min. which is less than 15 min.; therefore, it is not a reportable event. In the case of Set 2 readings, the time between the first and last reading exceeding 1.0 NTU is greater than 15 minutes (T=38 to T=54); therefore it is a reportable event when T=53.



Example 2 (see diagram below)

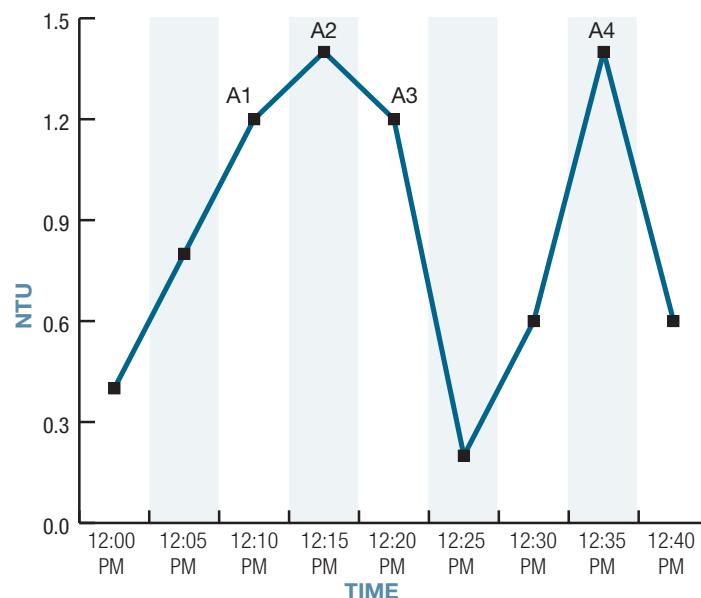
Polling frequency: 5 min.

Time between A1 and A2: 5 min. <15 min.

Time between A1 and A3: 10 min. <15 min.

Time between A3 and A4: 15 min.

Therefore, A4 is an adverse result at 12:35 AM and the test must be reported as adverse under **Schedule 16 16-3(1)6**.



Example 3 (see diagram below)

Polling frequency: 4 min.

Time between B1 and B2: 4 min.

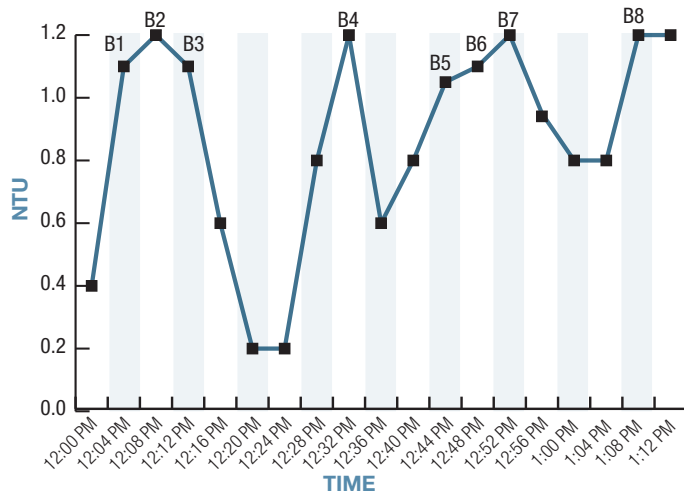
Time between B1 and B3: 8 min.

Time between B4 and B5: 12 min.; all less than 15 min.

Time between B4 and B6: 16 min. > 15 min

B6 is the first reading taken 15 or more min. after B4. Therefore, **B6 is an adverse result** at 12:48 AM and must be reported under **Schedule 16 16-3(1)6**

Although the 2 readings, B7 and B8, are 16 min. apart, the reading B8 at 1:08 AM is not reportable as the previous report was made at 12:48 AM, which is within 24 hours.



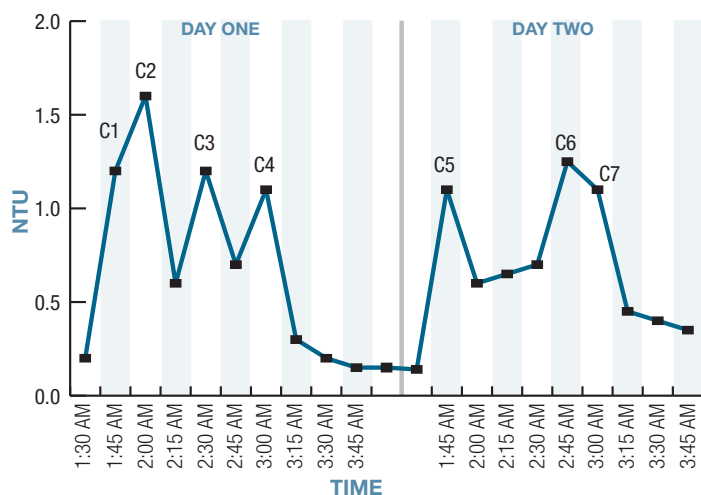
Example 4 (see diagram below)

A DWS takes a sample every 15 min. and records each turbidity test result as shown. The DWS sounds a regulatory alarm when it exceeds 1.0 NTU.

Time between C1 and C2 = 15 min.

C2 is an adverse result on Day1 at 2:00 AM and therefore, must be reported as adverse under **Schedule 16 16-3(1)6**.

C3, C4 and C5 are all > 1.0 NTU; but no two readings taken 15 min. apart are above 1.0 NTU. Also, readings are within 24 hours of reporting result C2. Therefore, C3, C4 and C5 are not reportable results.



Time between C6 and C7 = 15 min.

Time between C2 and C7 > 24 hours

C7 is an adverse result on Day 2 at 3:00 AM. Therefore, it must be reported as an adverse result under

Schedule 16 16-3(1)6.

5. Performance of Filtration Process

Pathogen removal credits are assigned to various treatment technologies in the Ministry's document, "*Procedure for Disinfection of Drinking Water in Ontario*" (PIBS 4448e01), as follows:

Treatment Technology	Log Removal Credit		
	Giardia Cysts	Viruses	Cryptosporidium Oocysts
Conventional Filtration	2.5	2	2
Direct Filtration	2	1	2
Slow Sand Filtration	2	2	2
Cartridge/Bag Filters	2.0 +	0	2
Membrane Filtration	3.0 +	0.0 to 2.0+	2

Conventional filtration is the most common treatment process currently used by DWS that rely on raw water supplies which are surface water. This treatment process consists of chemical coagulation, rapid mixing, flocculation and sedimentation followed by rapid sand filtration.

Performance Criteria for a Conventional Filtration System

In order to be considered conventional filtration and claim the 2 log Cryptosporidium oocyst removal, 2.5 log *Giardia* cysts removal and 2 log virus removal credits, the filtration process must meet the following criteria:

- use a chemical coagulant at all times when the treatment plant is in operation;
- monitor and adjust chemical dosages in response to variations in raw water quality;
- maintain effective backwash procedures, including filter-to-waste or an equivalent procedure during filter ripening to ensure that the effluent turbidity requirements are met at all times;
- continuously monitor filtrate turbidity from each filter; and,
- meet the performance criterion for filtered water turbidity of less than or equal to 0.3 NTU in 95% of the measurements each month.

To be able to assign filtration credits, all of the 5 criteria listed above must be met. The first 4 criteria are straight forward. Therefore, the details as to how to calculate the 95% are provided below:

6. 95% Performance Calculation

The filtration process that is to receive a pathogen removal credit refers to all the filters in operation and therefore, the 95% is calculated using all turbidity measurements taken in a calendar month from all filters that operated in the DWS during that month. For the purpose of determining compliance with this filtration process performance criterion, it is not necessary to calculate the 95% for each filter separately. In the calculation, use only the measurements taken when the particular filter effluent line is directing water to the next stage of the treatment process. Some DWS may be taking turbidity measurements even when the filter is either in backwash mode or in filter-to waste-mode. These “off-line” measurements are not to be included in the calculations.

Example

Adams Peek DWS is a conventional filtration system. It has 4 filters and effluent from the 4 filters is continuously monitored by 4 turbidity meters, each installed on the effluent line of a filter. It is determined that filters No.1, No.2, No.3 and No.4 were either in “backwash” mode or in “filter-to-waste” mode, for a total period of 10 hours, 8.5 hours, 9.25 hours and 9 hours, respectively, during the calendar month of June 2009. The SCADA system does not record any turbidity reading during this period. What is the performance of the filtration process at the Adams Peek DWS for the month of June 2009?

Case I:

The turbidity meters take a reading every 1 min.interval. The SCADA system records all 1 min. testing data, including time, filter number and turbidity reading in NTU when the filtered water is discharged to the next treatment process. The SCADA system also alarms and records any reading that exceeds 1.0 NTU.

Month: June 2009

Filter	Backwash/ Filter-to- waste (hrs) (from records)	# of turbidity measure- ments taken by turbidity meter	# of turbidity measure- ments > 0.3 NTU (observed)	# of turbidity measure- ments ≤ 0.3 NTU
No.1	10	42,600	500	42,100
No.2	8.5	42,690	650	42,040
No.3	9.25	42,645	400	42,245
No.4	9	42,660	300	42,360
All 4 filters		170,595		168,745

Actual filtration period for filter No.1 =

$\{[(30 \text{ days} \times 24) \text{ hr} - 10 \text{ hr}] \times 60\} \text{ min.}$

= 42,600 measurements (measurement every minute)

Percentage of measurements less than or equal to 0.3 NTU=
 $\{168,745/170,595\} \times 100 = 98.916 \% > 95 \%$

Case II:

The turbidity meters take readings every 30 seconds. The SCADA system takes all 30 second test data within a period of 15 min., calculates and records **maximum**, **minimum** and **mean** readings in NTU, at the end of the 15 min. period along with time and filter number. The readings are recorded only when the filtered water from the particular filter was discharged to the next treatment process during that 15 min. period. All of these recorded values (the **maximum**, **minimum** and **mean** values for each 15 min. period) are used in the monthly 95% calculations. The SCADA system also alarms and separately records any reading that exceeds 1 NTU. These separately recorded readings are not included in the calculations as they are a subset of all recorded readings and have already been accounted for.

Month: June 2009

Filter	Backwash/ Filter-to- waste (hrs) (from records)	# of turbidity measure- ments taken by turbidity meter*	# of turbidity measure- ments > 0.3 NTU (observed)	# of turbidity measure- ments ≤ 0.3 NTU
No.1	10	8,520	117	8,403
No.2	8.5	8,538	140	8,398
No.3	9.25	8,529	93	8,436
No.4	9	8,532	79	8,453
All 4 filters		34,119		33,690

*Number of all **maximum**, **minimum** and **mean**
3 measurements for each 15 min. interval

Number of measurements for filter No.1 =

$\{[(30 \text{ days} \times 24) \text{ hr} - 10 \text{ hr}] \times 4 \text{ times every hour} \times 3\} = 8,520$

Percentage of measurements less than or equal to 0.3 NTU= $\{33,690/34,119\} \times 100 = 98.74 \% > 95\%$

NOTE 1: In certain situations, a DWS owner may calculate the performance in percentage, for the filtration process on a daily basis. Then, calculate an average at the end of a calendar month. This calculation is also acceptable.

NOTE 2: In certain other situations, the SCADA system may record readings during backwash mode and filter-to- waste mode. Since water is wasted and not sent to the next treatment process, readings taken during this period should not be taken into the calculations.

NOTE 3: For DWS using other technologies, use the respective performance criteria specified in the disinfection procedure (eg. for membrane filtration, 0.1 NTU in 99% of the measurements).

7. Questions and Answers

If the filtration process of a DWS does not meet the 95 percent criterion for a calendar month, should it be reported under Schedule 16, section 16-4?

Section 16-4 is intended to address reporting an observation other than an adverse test result prescribed by section 16-3 indicating that a DWS that provides or is required to provide disinfection is directing water to system users that has not been disinfected in accordance with the Ministry's *"Procedure for Disinfection of Drinking Water in Ontario."* The 95 percent is one of the criteria required to be met to receive removal credits for a filtration process. If it is observed (by conducting the calculations for the month) that this criterion is not met, the filtration process can not claim the assigned pathogen removal credits for the calendar month.

However, the filtration process represents only one of the possible barriers in a DW treatment system and there may be other down stream treatment processes (such as primary chlorination, UV etc.) that may have compensated for the pathogen removal credits lost by the filtration process (by not meeting the 95 percent criterion) during the calendar month. Therefore, the operator must check the other barriers and assess their removal/inactivation credits and ensure that the DWS has met the overall treatment requirements. Once it is determined that the overall pathogen removal/inactivation requirements have not been met by the DWS for the calendar month, this must be reported immediately.

When exactly should the report be made?

Test results from a continuous monitoring equipment must be examined within 72 hours after the tests are completed (**Schedule 6, subsection 6-5 (1) 3**). Therefore, calculations for the performance of the filtration process using data from all continuous monitoring turbidity meters must be made within 72 hours after the end of each calendar month. If the calculation result for a particular month does not meet the 95 percent criterion and the down stream treatment processes have not compensated for the pathogen removal credits lost by the filtration process, the operator shall make a report to the Ministry, the medical officer of health and the owner of the DWS, immediately after the calculation and assessment is conducted.

What action must be taken if the filtration process of a DWS does not meet the necessary 95 percent performance criterion?

Once a report for water that has not been properly disinfected in terms of performance of filtration process has been made, the DWS owner and operating authority shall check and immediately restore proper disinfection (including proper filtration, which enables proper disinfection as well as contributes to the overall pathogen removal/inactivation) and take such other steps directed by the medical officer of health (**Schedule 17, 17-2**).

If the DWS has not met the overall pathogen removal/inactivation requirements, the owner and operator must check the operation of each filter for the preceding month, rationalise the cause for not meeting the filtration process performance and rectify the operation during the subsequent month.